

Applicant: Yang Chin Cheng.

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Amendments to the Claims

This listing of claims will replace all prior versions, and listings, of claims in the application:

Listing of Claims

1. (Currently Amended) A method for forming a semiconductor device, the method comprising:

providing a substrate;

forming a material layer over the substrate;

forming a patterned photoresist layer over the material layer;

exposing a top surface of the patterned photoresist layer to a treatment radiation to generate separate photoresist structures having first distances between corresponding points of the separate photoresist structures defining a first pitch;

performing an ultraviolet radiation exposure to reduce a cross-linked polymer state of the separate photoresist structures;

forming a protectant layer over the separate photoresist structures of the photoresist layer using a diffusion silylation process;

removing a portion of the protectant layer to expose an underlying portion of the photoresist layer;

removing the photoresist layer to form at least part of the protectant layer into separate protectant structures having second distances between corresponding points of the separate protectant structures defining a second pitch, the second pitch being less than the first pitch; and

removing portions of the material layer using the separate protectant structures as a mask.

2. (Previously Presented) The method as set forth in claim 1, wherein:

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the treatment radiation comprises light radiation;
the protectant layer comprises a silylated layer; and
the method comprises an additional step of removing the separate protectant structures.

3-7. (Cancelled)

8. (Original) The method as set forth in claim 2, wherein the photoresist layer is positive photoresist.

9. (Original) The method as set forth in claim 2, wherein the photoresist layer is positive e-beam photoresist.

10. (Previously Presented) The method as set forth in claim 2, wherein the exposing of the photoresist layer to treatment radiation comprises performing a flood exposure process to alter at least one property of the photoresist layer.

11. (Previously Presented) The method as set forth in claim 2, wherein the forming a silylated layer over the separate photoresist structures comprises silylanizing a surface of the separate photoresist structures.

12. (Previously Presented) The method as set forth in claim 11, wherein the silylanizing of a surface of the separate photoresist structures comprises a silylation process being performed in a gas phase.

13-16. (Cancelled)

17. (Currently Amended) A method comprising:
providing a substrate having a first layer formed thereon;
forming a patterned second layer on the first layer, the second layer comprising

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photoresist;
performing a treatment on the patterned second layer to form at least part of the second layer into separate structures having first distances between corresponding points of the separate structures defining a first pitch, reducing a cross-linked polymer state of the separate structures using ultraviolet radiation, and performing silylation to forming a protection layer over the second layer separate structures;

removing a first portion of the protection layer to expose the second layer separate structures;

removing the second layer separate structures to form at least part of the protection layer into separate protection structures having second distances between corresponding points of the separate protection structures defining a second pitch less than the first pitch; and

using the separate protection structures as an etch mask, removing an exposed portion of the first layer.

18. (Previously Presented) The method as set forth in claim 17, wherein:

the treatment comprises a flood exposure;

the protection layer comprises a silylated layer; and

the method comprises an additional step of removing the separate protection structures.

19. (Currently Amended) The method as set forth in claim 18, wherein:

the first layer is a material layer;

the second layer is a photoresist layer; and

the flood exposure comprises exposure to ultraviolet radiation and is performed substantially perpendicularly to the second layer so that a top surface of the second layer is exposed to the ultraviolet radiation.

20. (Cancelled)

21. (Previously Presented) The method of claim 18, wherein:

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the silylanizing of the second layer is performed in a gas phase or in a liquid phase;
the removing of the first portion of the silylated layer to expose the second layer
comprises using an etching back process or a chemical mechanical planarization process; and
the removing of the first portion of the silylated layer does not remove a substantial
portion of the second layer.

22. (Previously Presented) The method of claim 18, wherein:
the silylanizing of the second layer is performed in a gas phase or in a liquid phase;
the removing of the first portion of the silylated layer to expose the second layer
comprises using a dry etching process or a wet etching process;
the removing of the second layer comprises using a dry stripping process or a wet
stripping process; and
the removing of the second layer does not remove a substantial portion of the first layer.
23. (Previously Presented) The method of claim 18, wherein the removing of the separate
protection structures forms a plurality of structures having a pitch that is smaller than a
photolithography process will allow.
24. (Previously Presented) The method of claim 18, wherein the removing of the separate
protection structures does not remove a substantial portion of the substrate.
- 25-26. (Cancelled)
27. (Previously Presented) A method for forming a semiconductor device having a reduced
pitch, the method comprising:
forming a material layer on a substrate;
forming on the material layer a patterned photoresist layer of separate photoresist
structures having first distances between corresponding points of the separate photoresist
structures defining a first pitch;

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exposing the patterned photoresist layer to ultraviolet radiation to alter at least one property of the patterned photoresist layer so that a cross-link degree of a portion of the patterned photoresist layer is reduced;

silylanizing the patterned photoresist layer in a gas phase or in a liquid phase by diffusing silylamine into the patterned photoresist layer and forming a silylated layer over the surface;

removing a first portion of the silylated layer to expose the patterned photoresist layer using an etching back process or a chemical mechanical planarization process;

removing the patterned photoresist layer using a plasma gas to form at least part of the silylated layer into separate silylated structures having second distances between corresponding points of the separate silylated structures defining a second pitch, the second pitch being less than the first pitch;

using the separate silylated structures as an etch mask, removing an exposed portion of the material layer; and

removing the separate silylated structures thereby forming a plurality of separate material structures having the second pitch which is smaller than a photolithography process will allow.

28. (Previously Presented) The method of claim 27, wherein:

the plasma gas comprises oxygen; and

the removing of the separate silylated structures does not remove a substantial portion of the material layer.

29. (Previously Presented) The method as set forth in claim 2, wherein the material layer is selected from a group consisting of silicon, silicon dioxide, doped silicon dioxide, silicon nitride, poly silicon, aluminum, copper, titanium, titanium nitride, tantalum, and tantalum nitride.